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Construction of the State Armory At Patterson, N. J.

Civil Engineering
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CONSTRUCTION

OF THE

STATE ARMORY

AT

PATERSON, NEW JERSEY

BY

HUGO S. SPEIDEL

CLASS OF 1888

THESIS FOR THE DEGREE OF BACHELOR OF SCIENCE

IN CIVIL ENGINEERING

COLLEGE OF ENGINEERING

UNIVERSITY OF ILLINOIS

PRESENTED JUNE, 1904

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June 3, 1904 190

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

HUGO S. SPEIDEL, Class of 1888,

ENTITLED CONSTRUCTION OF THE STATE ARMORY AT PATERSON, NEW JERSEY

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science in Civil Engineering.

Ira O. Baker.

HEAD OF DEPARTMENT OF Civil Engineering.

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-Paterson Armory-

The armory of the National Guard of New Jersey at Paterson, New Jersey, was built under the direction of the State Armory Commission which commission has the supervision of all armories built in the state. Mr. Wm P. Field engineer for the commission prepared the plans and superintended the construction of the work.

The building is 250 feet long by 146 feet wide inside the walls and is constructed with brick enclosure walls, wood floors and slate roof, the latter supported on a frame-work of structural steel trusses and purlins.

The building is divided into two portions by a partition wall about fifty feet from the south ends the main portion forming the drill shed and the southerly end forming the administration building.

The structural steel work was done by the Passaic Rolling Mill Co. of Paterson N. J. (now The Passaic Steel Co.) under the supervision of the writer.

The structural steel work in the Administration building presents no unusual features, the floors being laid

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on steel beams which rest directly on the masonry walls and partitions.

The Drill Shed is approximately 200 feet long by 146 feet wide and in order to give an entirely clear floor space a number of long span trusses and other heavy steel work were required. A general plan of the framing is shown in Fig. I. The space is divided into six bays of 25 feet each and one double bay of 50 feet at the north end by a system of transverse trusses six in number with two hip trusses at the corners of the north end and two intermediate end trusses.

There are also at both ends smaller intermediate trusses or jack rafters, as shown on the plan. These trusses carry a system of lattice purlins upon which nailing strips of hard pine 3"×6" are bolted and to which the two inch roof boards are nailed.

The specifications for steelwork contained the following clauses, viz:-

Steel to be made by the open hearth process and to have an ultimate strength of from 58,000 lbs. to 66,000 lbs. per sq. inch

an elastic limit of not less than one half the ultimate strength and an elongation of 22 per cent in eight inches and shall bend 180 degrees around a curve of equal diameter to the thickness of the piece tested without sign of fracture.

It shall not contain more than .05 per cent of phosphorus for basic steel nor more than .08 per cent for acid steel.

Wrought iron shall have an ultimate strength of from 50,000 to 58,000 lbs. per sq. in. and shall be tough, fibrous and bend 180 degrees flat upon itself without sign of fracture when nicked on the outside of bend.

Rivet steel shall have an ultimate strength of not more than 58,000 lbs. per sq. in. an elastic limit of one half the ultimate strength and an elongation of 26 per cent in eight inches.

All pieces which have to be heated to bend must be subsequently annealed.

Holes must be punched $\frac{1}{16}$" less in diam. than the finished rivet and reamed to $\frac{1}{16}$" larger than finished rivet or be drilled from the solid and all holes

for field rivets must be reamed to an iron template ½" thick while the parts are held rigidly together."

Other clauses were of the usual character requiring the highest class of workmanship for this class of work.

As shown in the cross section of the bldg. Fig. 2 the main trusses were made in the form of a three hinged arch with a tie rod across the bottom to take up the thrust of the arches. They were built to come wholly inside and independent of the side walls so that deformations in the trusses due to temperature changes would not crack or effect the walls in any way.

The span from center to center of end pins is 140 feet and the rise center to center of pins is 65'-8". Starting from a point vertically over and 8'-0" above the end pin the form of each half truss on the center line is a parabola with the apex at the point just mentioned. The parabola then extends upward until it intersects the parabola of the other half truss in the center pin at the peak of the roof. The trusses are of varying depth starting at

5'-0" at the point where the curve begins and decreasing gradually toward the peak where they are 4'-6" in depth. The section is a latticed box girder, each flange of which is made up of two web plates, two angles and a cover plate and the web members of two angles latticed. Fig. 2 shows the form of truss and the system of web bracing employed while Fig. 3. is an enlarged detail of the lower portion of truss and pin joint. Each half truss is spliced at about the center with a splice which develops the full section cut.

As shown in the cross section the tie rods connecting the lower pins are beneath the floor and supported at intervals on cast iron chairs to keep them from sagging unduly.

The trusses were designed for a wind load of 40 lbs. in addition to a snow load of 20 lbs. and the dead load of the structure. Allowable tension was placed at the low limit of 7,500 lbs per sq. in. and compression at 7,500 lbs. per sq. in. reduced by Gordons formula. This has resulted in a very heavy steel structure and while substantial has the effect of making the hall look

lower than it really is and of taking up too much room on the floor where the trusses come down to the floor.

When the work of detailing the trusses was started in the draughting room it was soon found that owing to the length of each truss and more still to the constantly varying curvature of the truss it would be impracticable to make working detail drawings in the usual way and it was finally decided to make only a detail giving the thickness of gusset plates and number of rivets required at each joint. Ordinates to the curve from a chord connecting the end and center pins were then calculated and with this information the work was transfered to the template shop.

On the floor of the template shop the pin centers of the half truss were laid out and the ordinates of curve accurately plotted with the use of an engineers transit and then the templates were marked out and cut. Measurements were then made of all members and of the size and shape of all gusset plates

so that the material could be ordered without waste the same as if they had been ordered from detail drawings.

However as the contract for the steel work included furnishing a set of detail drawings to be filed with the records of the Commission, the usual procedure of making templates from detail drawings was reversed and the drawings were made from the measurements taken from the templates or from the actual trusses themselves as they were assembled in the shop.

The hip and end half trusses are similar in form to the main transverse trusses and were constructed in the same way. The small trusses at the south end abut against the partition wall and masonry buttresses were built back of the wall to take up the thrust from these trusses.

The purlins are built in the form of a latticed girder and act as struts for the bracing of the roof trusses. Top and bottom chords of the purlins are 2L's 4"×3"×$\frac{3}{8}$" latticed with a double system of angles 3"×3"×$\frac{3}{8}$"

They vary in depth from 3'6" to 4'6"

according to their location and the position they hold with respect to the truss. They are all set vertically instead of being inclined normally to the roof and as the roof had a straight pitch from peak to eave it was necessary to frame out from the trusses at the haunches to support the purlins.

There is a system of lateral bracing throughout between all roof trusses consisting of steel rods 1½" diam. with upset ends and fitted with turn buckles for adjustment.

The shoes on which the main trusses rest are of the ordinary type of bridge truss shoes built up of plates and angles. The bottom plate of shoes is 2'-3" × 3'-6" and is anchored to the foundation with four bolts 2½" diam. and six feet long. The pins at both foot and peak are 5 15/16" diam. The tie rods connecting the lower pins of the main trusses are 2¼" diam. and made in sections about thirty feet long upset at each end to 2¾" and connected with standard sleeve nuts.

The top of the building is surmounted by a ventilating monitor 35 feet wide and nine feet high the frame of which is made of double angles 4" × 3" × ⅜" for chords

and single angles 3"×3"×$\frac{3}{8}$" for diagonals.

The monitor is braced longitudinally with purlins similar to the purlins of the main roof and braced laterally with one inch rods of wrought iron fitted with adjustable clevises. The windows of the monitor are opened and closed in lengths of about twelve feet by worm gear operated from a small foot walk provided for that purpose.

Along both sides and at each end of the main drill shed is provided a gallery. The side galleries are 9'-0" wide and are on latticed girders framed in between the trusses except the front girders which are supported on cantilever brackets extending out from the trusses. The front girders are made in a somewhat ornamental style and form the railing of the gallery. The other girders supporting the side galleries are made up of 4 L^s 6"×4"×$\frac{3}{8}$" latticed with 5"×3"×$\frac{3}{8}$" L^s and are 26" deep. The end galleries are supported on girders, one end of which rests on the walls and the other end is hung from the trusses at intervals of 20 feet by rods varying in diam. from 1$\frac{3}{4}$" to 2$\frac{5}{8}$" and upset

as in the case of the arch ties. Between these main girders are framed lattice girders similar to those supporting the side galleries.

In calculating the stresses in trusses and girders the load on these galleries in addition to the dead load of the structure was taken at 100 lbs. per sq. ft.

Although the site of the Armory was only about a mile and a quarter from the mill the trusses were loaded on cars and shipped to a point about 400 yards from the site and from there were carted to the building.

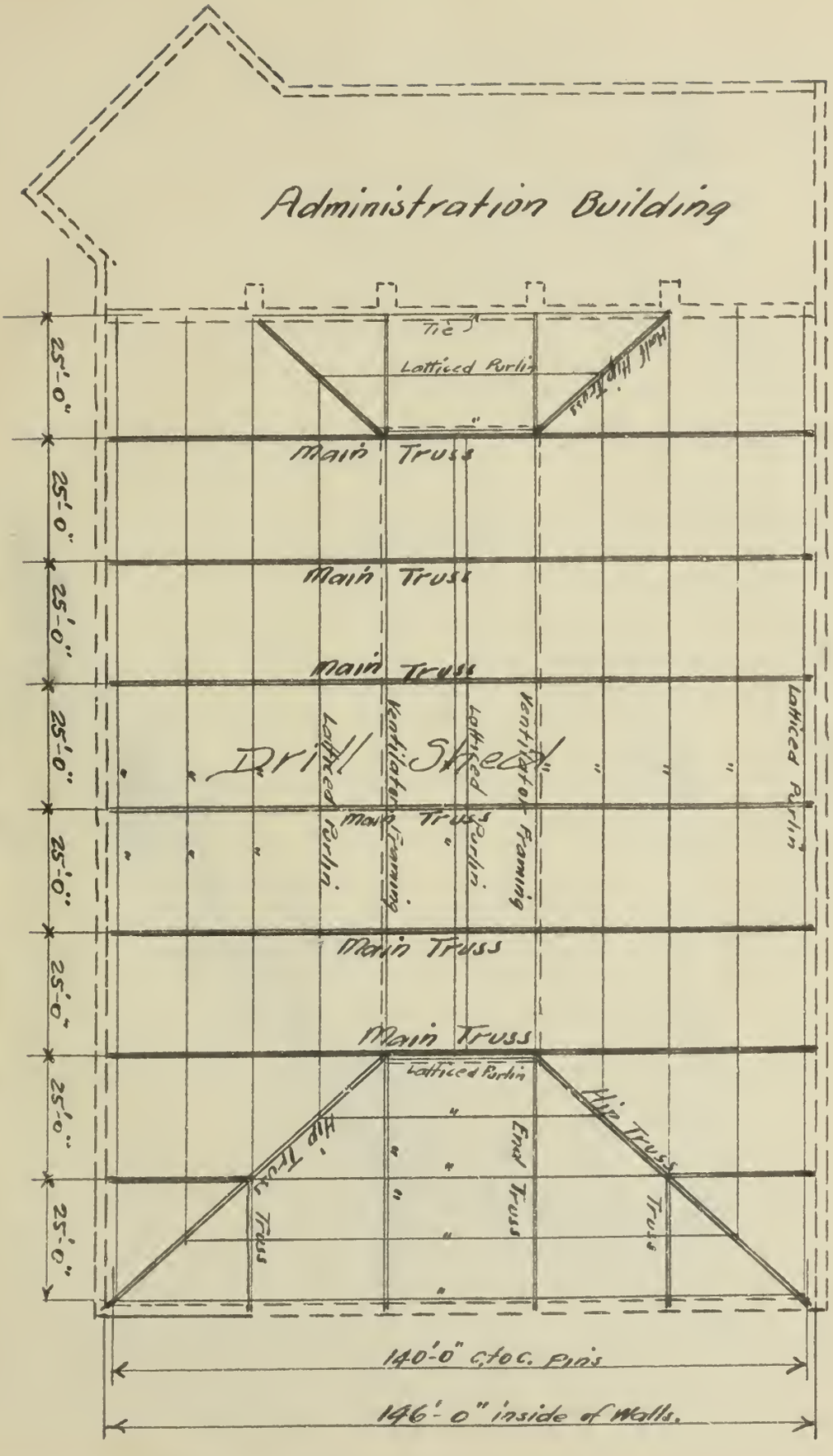
The erection was carried on by means of two sets of travellers, one running on the ground and acting as a falsework to hold the half arches in place until the other half could be put up and connected and the other one running along the top of the trusses on a temporary track laid on two of the purlins. This later traveller was provided with two 35 ft. boom derricks and with it one half of the next truss to be erected was lifted as well as all the light parts such as purlins, bracing etc.

The lower traveller had a mast of 16"×16" yellow pine with which most of the heavy

lifting was done. No difficulty was experienced in bringing the holes for field riveting together as all the joints had been reamed while held together at the shop. In such places as riveting was impossible turned bolts were used for field connections and they were taken at three fourths of the value of rivets.

The steel work of the entire structure weighed 1,360,840 lbs. and the contract price was $40,215.00 erected and painted making the price about $59.00 per ton which is much cheaper than the same class of work could be done to-day, although it would have been possible to have lightened the steel work by allowing a somewhat larger working stress in the material so as to reduce the price by about one fourth and still have had a perfectly safe structure.

Hugo S. Sheidel



General Plan of Roof Framing
Paterson Armory
Scale 1/32" = 1'-0"

Fig. I.

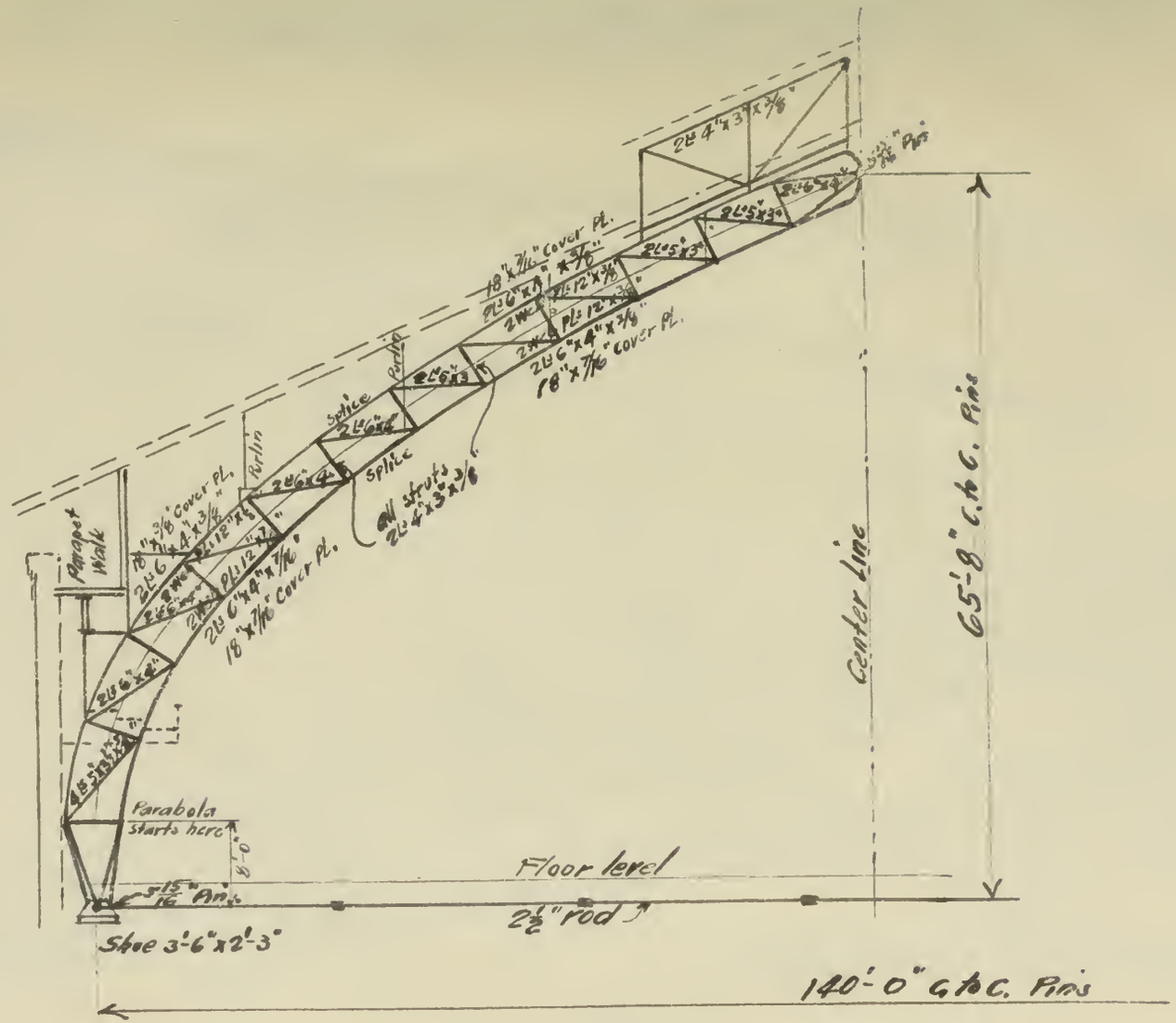
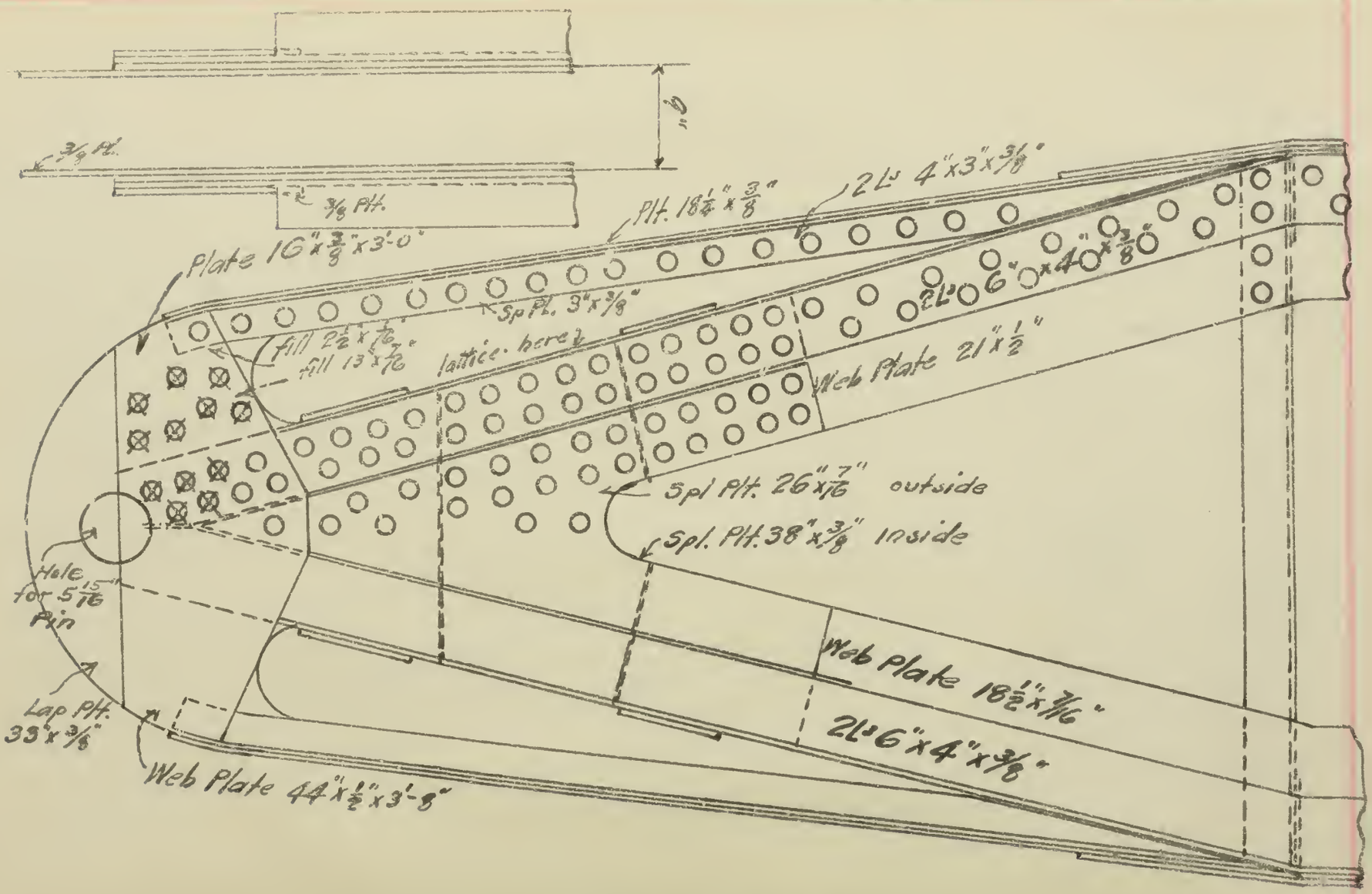


Fig. 2.

Half Transverse Section
Paterson Armory.

Scale 1/16"=1'0"



Detail at Foot of Trusses
Paterson Armory

Fig. 3.

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